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THE SOUTH-WEST BORDERLANDS OF THE RUB' AL KHALI

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121 126 AS A RESULT of work carried out for the Desert Locust Survey in south-western Arabia during the past few years, several of the blanks on the map have been filled in and much confirmation has been given to previous travellers' reports. The region particularly investigated has been that which forms the transition belt from the peripheral mountain system to the interior sand desert often referred to as the Rub' al Khali. The area visited has been mapped on a scale of 1:500,000 by means of car-compass traverses tied to astronomically determined positions, all to a general accuracy of 0·1 of a mile. The following notes are intended only to supplement the information contained in those maps which are in process of publication.

The mountain systems

183 The old crystalline hills of the 'Asir and Yemen, which to the west drop in a series of steps to the Tihamah or coastal plain, are to the east overlain by near horizontal strata of sedimentary rocks of which the oldest are probably the sandstones forming the Kaukab plateau and the newest, excluding recent deposits, are the Eocene limestones of the *jol*, the succession seeming more complete in the north. The peripheral mountain system is in the form of a letter L, where the upright stroke comprises the 'Asir and the Yemen mountains and the horizontal stroke is the *jol* plateau, the division being more or less abrupt along the line of the forty-seventh meridian.

Philby (1938) describes the change between the two sides of the 'Asir watershed as "abruptly from a tropical country to a desert plateau of uniform height of over eight thousand feet (with higher ridges), descending to about six thousand feet at the western end of the Najran tract. It is a sandstone area with occasional cappings and peaks of basalt. Its rugged gorges and valleys have occasional wells and springs, but for the most part it is an abomination of desolation extending north-ward to Dhahran and south-ward to the limit of vision into the still unexplored territory of northern Yemen." Nevertheless there are among the eastern slopes many wadis whose seasonal floods may rush out of the mountainous regions to the inland plain and on into the sandy desert.

The regularity of these floods in the past may be deduced from the extent of the thick layers of silt which mark the sites of past damming and irrigation works in nearly all these wadis. These silt layers often form 20-foot cliffs containing the present watercourses, and occasionally the ruins of the dams themselves may be found. The Wadis Habauna and Najran, besides having silt cliffs, show signs of further re-cutting of their outwash plains. In both cases the outwash plain extends regularly for the first 10 miles from the foothills but during the next 5 miles is eroded by gullies some 3 feet deep which together form a plain at a lower level, only to be re-cut in the same manner.

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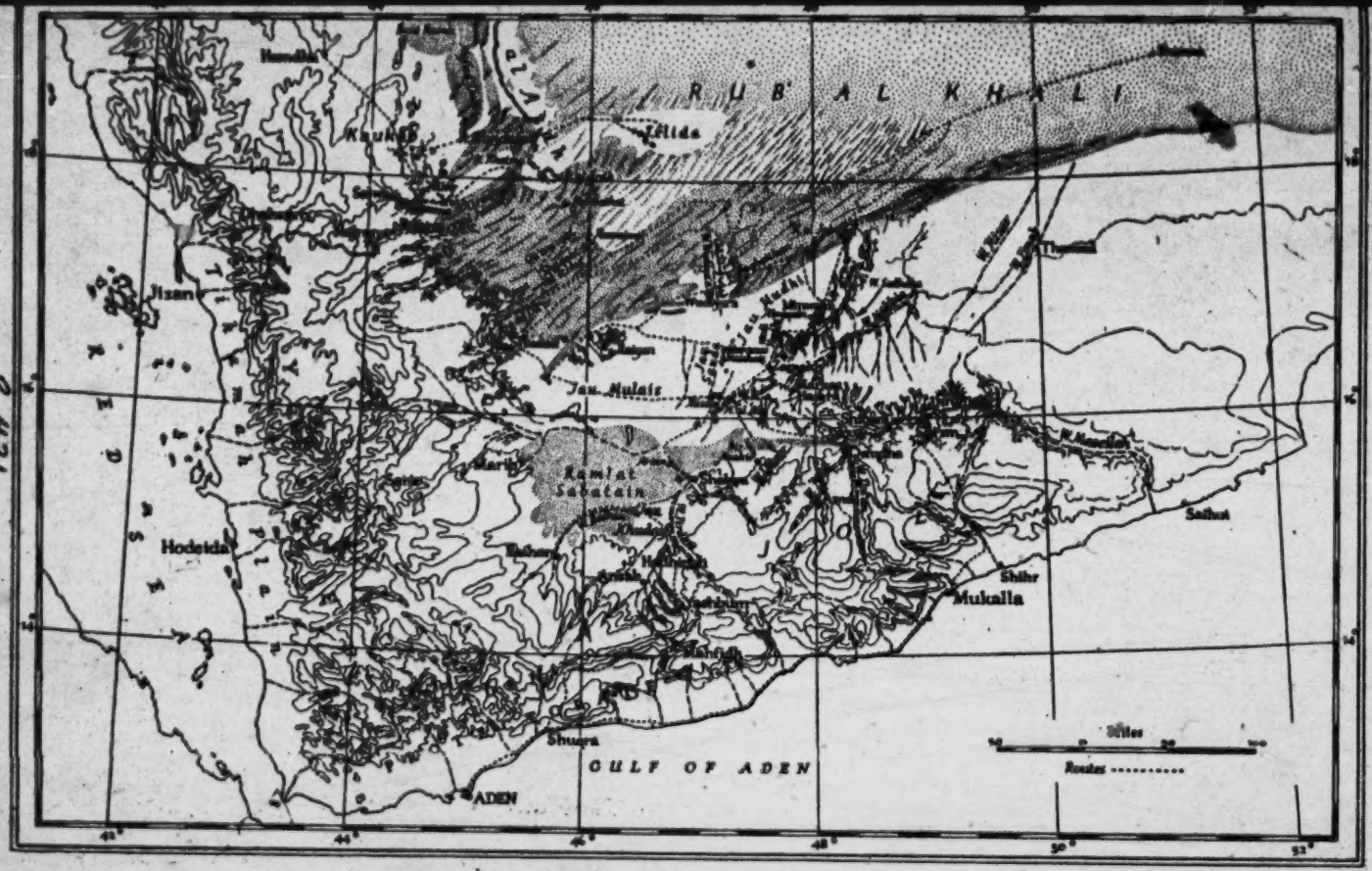

South-west borderlands of the Rub' al Khali

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133 In those parts visited, three such steps were noted in Wadi Najran and two in Wadi Habauna.

The line of the eastern foothills of the 'Asir and Yemen mountains continues in a curve south-east from Najran through Marib and Baihan to Al Hadhinah, about 14° 30′ N, 46° 50′ E. From here southwards through Mahfadh to the coast the crystalline rocks disappear under the cover of horizontal strata of nodular Eocene limestone which forms the plateau of the *jol*. The western limit of this *jol* continues north-east from Al Hadhinah to the Khashm al Jebel, 17° 30′ N.

At the Khashm al Jebel the plateau has an elevation a little over 2000 feet rising gently south-south-westwards till at 16° N. the altitude is 3000 feet at Sa[illegible] and 3400 by Markaz Hajar and Husn al 'Abr. South of the Wadi Hadh[illegible]haut the strata continue to rise until some 40 miles inland from the coast, where an increasing amount of faulting occurs and blocks of the *jol* have been forced to heights of over 6000 feet. Here too begins the volcanic activity evidenced by lava flows and signs of contact metamorphism, with a thin stratum of limestone overlying the igneous rocks (Plate 1).

The wadis of the jol

The deeply incised wadi courses which descend through the *jol* in a series of steps between high cliffs have excited the curiosity of travellers from the earliest times (Plate 2). The Bents (1900) thought that the erosion had been caused by marine action, but the general theory of climatic fluctuations has since suggested that there may have been sufficient rain in the past to have produced the present landform. Fisher (1951) remarks that the feature of the wide upper reaches of the Wadi Hadhramaut would seem to be the result of wadi capture, and it is suggested that this theory can be elaborated to account for the whole pattern of the present *jol* drainage.

The original drainage was north and south from the 6000-foot watershed. There may have been an east–west fault along the line of the present Wadi Hadhramaut which caused the north-flowing rivers each to have a short eastward reach along the line of the fault before continuing north again. One of the south-flowing rivers, the Maseilah, cut back through the main watershed at about 15° 40′ N., 50° 50′ E. and initiated the series of river captures on a line parallel to and inland of the watershed. In this it would have been helped by the existence of a fault line or similar line of weakness, though the absence of such a line of weakness does not materially affect or invalidate the hypothesis. The west–east course of the Hadhramaut–Maseilah system formed in this way dominates the present drainage pattern. The upper reaches of the north-flowing rivers would now have become north-flowing tributaries to the Wadi Hadhramaut, while the lower reaches would have been left headless or formed their own much shallower heads at the subsidiary watershed now created to the north of the Hadhramaut. This is supported by the statement by Thesiger (1949) that "the wadis flowing north from the Hadhramaut watershed are shallow at their heads, in contrast with the north-flowing wadis from Dhufar which begin in deep canyons." Once the north-flowing wadis from Dhufar are compared with the north-flowing wadis from the main watershed, *i.e.* the north-flowing tributaries to the Wadi Hadhra-

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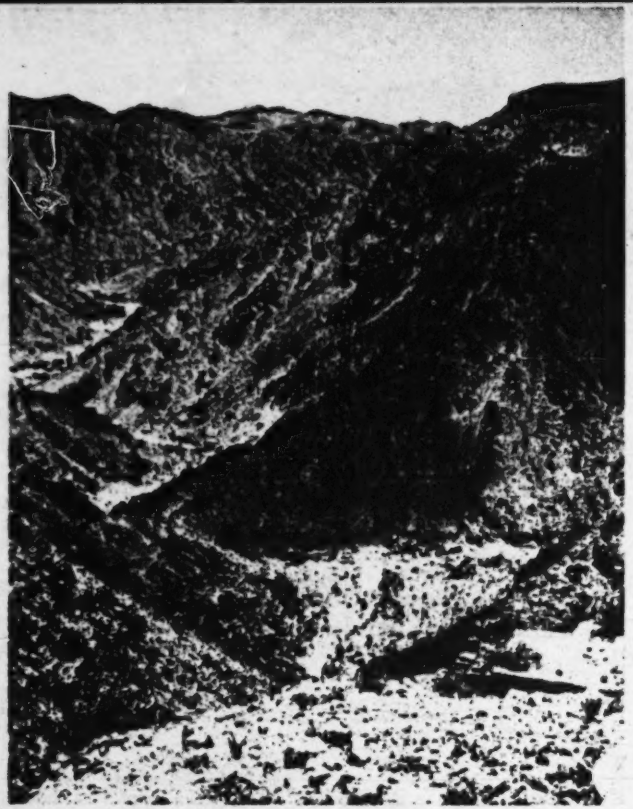

1. Thin stratum of limestone (top right-hand corner) overlying igneous rocks, on the west road from Mukalla

2. Part of the jol with the Wadi Hadhramaut, east of Tarim. The cliffs are approximately 1000 ~~feet high~~

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3. A typical town on unproductive land in the Wadi Du'an

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4. Part of the "Assoda" scarp seen from the Uruq az Zaza dunes. The scarp can be seen as a black line on horizon level. Vegetation is largely Calligonum comosum, Dipterygium glaucum and Cyperus sp.

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maut, and not with their beheaded remnants north of the subsidiary watershed, then the similarity becomes obvious. As would be expected from this theory, the south-flowing tributaries to the Wadi Hadhramaut have heads even deeper than those on the main watershed. Given a short eastward displacement in the courses of the original rivers, then it is possible that the Du'an and 'Amd drainages originally fed into the Hizar and Jinab respectively.

The completion of the present phase of river capture occurred when the headwaters of the Hadhramaut cut right back and out of the western edge of the *jol*, and formed the unusual and almost unique feature of the wide upper reaches in a line from Husn al 'Abr to Shabwa. The headwaters cut back rapidly across the plain which had been formed by the wadis 'Arma, Jirdan, Baihan, etc., and carried all the waters from them down to the Maseilah and the Gulf of Aden, whereas before they had drained towards the Persian Gulf. This capture has left a vast dry plain, the Khudaif–Mulais basin, with dry watercourses up to 2 miles wide. Several such courses may be seen in the Wudiya'a area, and have banks 20 feet or more deep, and floors of heavy fluvial gravels.

A series of levels carried out in early 1951 showed river capture still occurring around Husn al 'Abr. Here short, steep-profiled tributaries to the Wadi Hadhramaut are cutting back into the headwaters of the Wadi Hudhi, which flows north-eastwards past Zamakh with the cliff edge of the *jol* forming its right bank. Hills such as the Misair group have been isolated from the rest of the *jol*, and both Misair and Rubah retain the flat-topped character of the *jol*. The cliff face of Rubah is only some 200 feet high on the north where it descends to the Hudhi, but on the south it drops 500 feet to the Hadhramaut. Levels were also carried out in the Minwakh area and showed the capture of the lower waters of the Hudhi and the waters of the Sibr, Kor, Sulhaba, etc., which had been tributary to it. The point of capture of these rivers by the Aiwat as Sei'ar is at Shasun, about 10 miles downstream from Minwakh

The pattern of settlements

The siting of settlements in the mountain areas is dependent on agriculture with its requirement of a workable tilth and water at a manageable depth. Among the crystalline hills these conditions are best fulfilled at the foot of the torrent course, where the first patches of riverine plain appear. Thus there is a series of settlements from Ranya through Bisha, Tathlith, Hamdha, Salwa, Najran, Shudaif, Marib, Baihan, and Ansab to Al Hadhinah, and all these settlements can be reached by motor transport from the inland plain by driving up the wadi bed. Penetration upstream of the settlements is frequently difficult as the bed becomes stony and boulder-strewn, and all pretence of riverine plain ceases.

In the *jol* the wadis descend in a series of steps which are caused by strata more resistant to erosion. The horizontal section of each of these steps has retained sufficient silt for agriculture and water is also available. Moreover the vertical cliff faces, sometimes higher than the width of the valleys they contain, cut off the morning and afternoon sun, thereby considerably reducing

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133 the amount of evaporation. Accordingly we find in the north–south wadis a
311 continuous belt of cultivations with hamlets of a few houses every mile and towns about 15 miles or an easy day's walk apart. As opposed to this the cultivations in the Wadi Hadhramaut, which runs west–east, are to be found mainly in belts along the northern and southern sides, the south belt being wider than the north, due to the increasing evaporation and lower water table towards the centre of the wadi.

311 Except for the hamlets which occur among the fields, the buildings make
361 use of unproductive land, and perch up against the cliff side on the talus slope. This position also carries the advantages of shade together with good siting for defence. Where land is at a premium, villages may be so sited as to become inaccessible even to the draught and load-carrying beasts used in agriculture, and the stables and grainstores are found at the edges of the fields and at the foot of the narrow winding path leading up to the village (Plate 3).

[104] Water for the permanent cultivations of *dhurra* (*Sorghum* sp.), *dukhn*
312 (*Pennisetum typhoideum* et spp.), lucerne and date palm has until the last few
406 years been drawn by man or animal power, raising a leather bag of water by
241 walking down a ramp away from the well shaft. Nowadays greater use is being made of diesel- and petrol-driven pumps, increasing both the yield and the area it is economical to cultivate. The effect of these pumps, which are available on deferred terms, in lowering the water table will be watched with care. New crops such as potatoes, the brassicas, and sugar cane are also being introduced under the agriculture scheme in an attempt to make the Hadhramaut, if not entirely self-supporting, at least less dependent on its "extra-territorial population."

241 This limitation does not apply to the flood crops which are snatched
312 wherever possible. Throughout the lower wadi systems there exists a com-
361 plicated network of deflector dams which have the object of spreading the floodwaters over as large an area as possible, and leading a certain part of them into irrigation channels. Many retaining dams have been attempted, but usually unsuccessfully, as the major structure has been an earthwork with only the spillway of durable construction. In the shallow beds of the wadis running north from the secondary watershed there are many small cultivated patches and groups of two or three fortified houses are often situated where camel tracks converge on water cisterns cut into the rock.

The transition belt.

133 The transition zone between the mountain systems and the sand desert takes a number of forms. North of the Ramlat[1] al Mundafan the Kaukab sandstone plateau overlies the crystalline rocks to the west, and to the east has eroded to become an area of minor plateaus and blocks. Through the wide flat valleys between these minor plateaus runs the main Najran–Dawasir track, roughly north–south in longitude 44° 45′ E. at a general height of a little under 3000 feet. To the east of this track lies the southern section of the Nafud Dahi, running parallel with the road, and rising to a height of 100 feet

104 [1] Ramla(t): a general name for any sand feature. Thus the Ramlat al Mundafan means literally "the buried sands."

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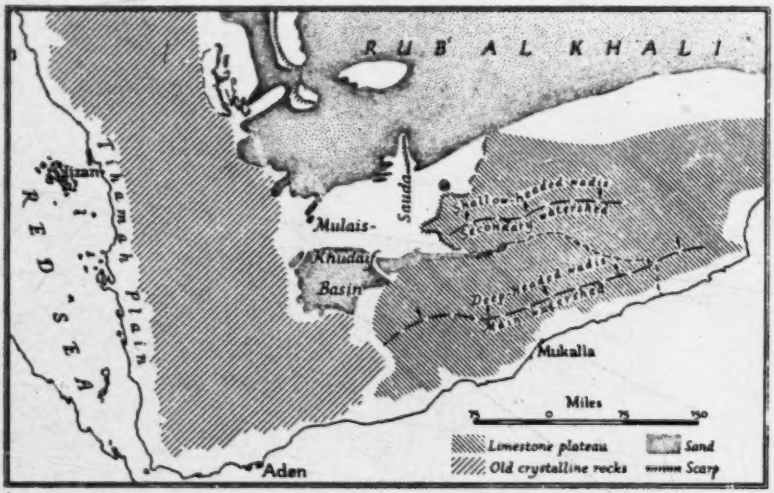
above it. It is a sandstone feature some 25 miles wide and has a covering of loose sand which tends to conceal its structure. However the sand cover becomes so thin along the highest part that the vegetation takes on a reticulated pattern in conformity with the fissure pattern of the sandstone below, suggesting that the ridge is either a shallow anticline or more probably a low west-facing escarpment concealed by the surfacing of loose sand. On the most southerly extension of the Nafud Dahi there are a few parallel dune chains oriented to 220° and 1 to 2 miles in length with a lateral spacing of 1 mile between groups. The slip faces are to the south-east, and the dunes about 20 feet high. According to local information the dunes are more



South-west borderlands of the Rub' al Khali: geological detail

abundant to the north, and the orientation of the Beni Rumh sands is to the north-west, but this area was not visited.

To the east, the Nafud Dahi descends easily to a north–south plain some 10 miles wide and 100 miles long lying at a height of 2600 feet at the foot of the Ardh scarp. This scarp, which is the southward continuation of the Jebel Tuwaiq, is of possibly Triassic calcareous felspathic sandstone overlain by a sheet of Jurassic limestone of great purity but covered by "desert varnish" giving it the appearance of old ivory. The scarp varies from 200 to 250 feet in height and between 19° and 20° N. lies in longitude 45° 10′ E., interrupted in 19° 53′ N. by the Wadi Fau. South of 19° N. the scarp turns to the south-east, loses height due to the east-north-east dip, and reaches 18° 32′ N., 45° 25′ E. The parallel dune chains of the sand desert proper lie on top of the scarp and from 2 to 4 miles back from the edge, with the exception of one line, the Ramlat al Mundafan which, in line with the ends of the other dunes, disappears into a depression of the Ardh scarp known as the Muqta'a al Tuwaiq, 18° 30′ N., 45° 30′ E. and continues, "buried" from sight, out on to the plain at the foot of the scarp. Motor transport can be taken up the scarp at this point.

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scarp at this point. The general alignment of the dunes is to 245° with the slip face to the north-west. The height is about 70 feet. As the Mundafan sands continue south-west they become divided into two sections by the *'asfal*[1] Wadi Habauna, a flat gravel plain on which no sign can be found of the Nafud Dahi scarp. The northern section continues unbroken to the eastern edge of the Ukhr block, a sandstone feature separated from the Kaukab plateau.

South of the *'asfal* Wadi Habauna as far as Shudaif the character of the transition zone is entirely different. Here parallel dunes reach right across to the foothills of the 'Asir and Yemen mountains leaving at the most a narrow plain but a few miles wide. For upwards of 20 miles from the base of the mountains, isolated granite crags may be found between and among the sand dunes. Driving through this area frequent detours have to be made out into the sands or in among the foothills to avoid the barrier formed by sand meeting hill. To pass the south-western end of the 'Arq ad Da'ir in 1952 necessitated a journey 6 miles further into the foothills than that recorded by Philby in 1936.

Shudaif marks the southern limit of the Rub' al Khali sands, and from here south-east stretches a vast triangular area of plains bounded to the north by the sands, to the east by the cliff wall of the *jol*, and to the south-west by the Yemen mountains. It has an area in the order of 150,000 square miles, and is divided into three sections, the Jau[2] Mulais, the Jau Khudaif and the Jau Hudhi by the Ramlat Sabatain and the Sauda scarp, which runs west and north respectively from Husn al 'Abr. The process of formation probably took place in three stages, of which the first was the planation of the archaean rocks before the deposition of the sedimentary strata. The second was the removal of this sedimentary cover by north-flowing wadis which were constantly forced against their eastern banks by the east-north-east dip of the underlying rock surface. Two river courses may still be seen doing this, the Hudhi cutting back the *jol*, and the abandoned course by Wudiya'a (see p. 423) which cut back the Sauda scarp. The third stage is the present one of arid erosion, where on the Jau Mulais the igneous protrusions are disintegrating by exfoliation down to a base level where they become protected from the great diurnal temperature changes by the sands and gravels of the desert floor, and on the Jau Hudhi above the Sauda scarp wind erosion is making the surface more and more smooth and level.

The Jau Khudaif and the Jau Mulais together form the Khudaif-Mulais basin referred to above (p. 423). The Jau Mulais is an area of quartz gravels, covered in some places by thin sheets of sand with areas of rock protruding from a few inches to a few feet. A few larger plugs and dykes form conspicuous hills such as the Raiyan group, which is in the form of a series of lines radiating from a point about 16° 30′ N., 46° 10′ E., the granite hills rising sheer from the plain made from their own disintegration. The Jau Khudaif lies to the south of the Jau Mulais and is divided from it by the Ramlat Sabatain. There is a greater cover of sand than on the Jau Mulais,

[1] 'Asfal: the lower reaches and outwash plain of a wadi.

[2] Jau: literally a wide valley here becomes applied only to these extensive plains formed by the merging of many watercourses.

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5. *Sandy shaqqa[1] bearing Aristida plumosa and Calligonum comosum. These shiqaq extend for hundreds of miles between parallel dune chains, and vary between a half and two miles in width*

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6. *Dune chains by the neolithic site in the Shaqqat al Khareitah. The dunes run to the south-west and the photograph was taken looking north*

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[1][The 'valleys' between parallel dune chains -- Analyst]

7. Dune chains north of the Khashm al Jebel. The shaqqa is about half a mile wide

8. Some of the dunes across the shaqqa floor of sand, about 100 miles west of Shanna

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133 and besides the granite foothills to the south-west there is a line of hills formed by salt domes along the foot of the *jol* to the south-east. In this area too may be found lignite deposits and occasional volcanic craters.

The sands of the Ramlat Sabatain lie east–west south of the 16th parallel, and are completely separate from the sands of the Rub' al Khali. In the west, where they lie against the Yemen hills, they measure some 50 miles in width from north to south. To the east they taper to a width of about 10 miles where they enter the Wadi Hadhramaut, and then lie within the wadi as far east as Qa'udha with isolated sections even farther east by Shibam and Sai'un. Near Baihan and near Shabwa the orientation of the dunes is to 290°, with the slip face southwards. Near Shabwa this direction has been used to give an easy crossing from Nasar to Arain, and between the dunes may be found a well marked camel track which was possibly part of the old incense route. South of al 'Abr the dunes lie at 230° and from here curve in a large arc east and south-east until they run almost due south to near Bir 'Asakir. From the east–west section another group of dunes breaks off to run in a similar curve south into the mouth of Wadi Dhuhr. Farther east the alignment is east–west and south of Qarn Qaima there is a reticulated area of overlapping crescentic dunes about 8 feet high and with their slip faces west.

Many wadis from the Yemen hills run into the western section of the Ramlat Sabatain and are dissipated within the sands, but the Wadi Baihan [137] forces its way through the sands in a series of deep silty channels between the [104] dunes which are here fixed by bushes of *arta* (*Calligonum comosum*) and runs out on to the Jau Khudaif. By using this wadi, Baihan can be reached from the Wadi Hadhramaut and also from Aden by the new route from Mahfadh, which makes use of the Yashbum gorge and the line of discontinuity between the crystalline hills and the *jol*.

North of the Ramlat Sabatain, the Jau Mulais is limited to the east by the Sauda scarp. This scarp, which is of sandstones similar to those of the Karoo and possibly of Triassic origin, runs north from near Al 'Abr and includes the hills of Murassas, Maishatt, Wudiya'a, etc. It gets its name Sauda, literally "the black," from its covering of hardpan and pebbles heavily impregnated with ilmenite (Plate 4). Its position marks the westerly limit of limestones, both Jurassic and Eocene, remnants of each of which, much confused with bands of contemporary sandstones, have been found near Wudiya'a. The whole of the Sauda area is covered with a network of intersecting animal tracks converging on salt-licks, proof that the region was once much more prolific of wild life.

133 137 East of the Sauda lies the Jau Hudhi, an undulating sand plain whose low hill features may easily be correlated with past drainage patterns. The larger of these hills sometimes bear fragmentary remains of limestone capping in the form of small boulders. From the air distinctive vegetation patterns have been seen near Zamakh. They consist of parallel lines some 30 yards apart running north-west to south-east. There is also one west-flowing tributary from this area to the abandoned watercourse at the foot of the Sauda scarp.

133 At the Khashm al Jebel, 17° 30′ N., 48° 17′ E., the Jau Hudhi ends in a sharp point at a height of a little over 2000 feet, being limited to the east by the cliff face of the *jol*, here about 120 feet high, and to the north by the first

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dunes of the Rub' al Khali. East of the Khashm al Jebel for over 50 miles to the mouth of Wadi Hizar the sands lie in contact with and to some extent overlying the low northern outcrops of the *jol*. These outcrops are in the form of flat-topped mounds covered with coarse pebbles of reddish marl with some thin sheets of limestone. East of Wadi Hizar the transition zone takes a further form as the outliers of the *jol* run in a line south of east and the sands in a line north of east, leaving a widening floor of gravel and desert marl. The plain is about 30 miles wide near Thamud and is reported by Thomas (1932) and by Thesiger (1946) to continue east to the Jiddat al Harasis.[1]

The south-western sands

The area of sands visited has been to the south of the 20th parallel and west of the 51st meridian. Throughout the whole of this area the sand pattern is one of parallel dune chains oriented generally from east-north-east to west-south-west and separated by long strips of flat desert floor known as *shiqaq*[2] (Plate 5). The tails of these dunes lie among the Yemen foothills and several crossings of the dunes have been made, up to 150 miles from the hills. The twenty or thirty southernmost dunes have been traced some 400 miles east to the vicinity of Shanna. In addition a large part of the area has been seen from the air.

The northern section of the Mundafan sands and the Ardh escarpment has already been described (p. 425–6). The southern section of the Mundafan sands are oriented to 205° and this orientation continues south through the 'Uruq al Juweis while other dunes break away to the north at an angle of 220°, parallel to the dunes of that section of the Mundafan which lies to the north of the *'asfal* Wadi Habauna. The slip faces of all these dunes are to the north-west.

South of the Mundafan sands the Ardh escarpment reappears running south from 18° 25′ N., 45° 27′ E. to the Khashm Khatma and then south-west losing height and disappearing into the desert floor at the Khashm al Ardh, 18° 01′ N., 45° 42′ E. This reappearance of the scarp breaks the continuity of the dunes which lie parallel to and south of the Mundafan sands, and leaves sand-free areas both on top of and at the foot of the scarp as with the northern section of the Ardh. A few outcrops of the Ardh occur southwards among the dunes, but do not break the continuity of the dune lines. In particular may be noted the Mutbathat group among which may be found traces of the old course of the Wadi Najran, and the Huwimil group at 17° 30′ N., 46° 00′ E. The final trace of the Jurassic limestones occurs at Abraqain near Wudiya'a.

Dune chains from the Khashm al Ardh may be traced south-west to the area of the wadi Taiyyibat al 'Ism and north-east to the Jilida plain. There is a well-marked motor track made by hunting parties leading to the Jilida plain from Najran via the *shiqaq* between these dunes. By the Khashm al Ardh the dunes are oriented to 220° with the dunes half a mile apart and the

[1] Later journeys (1953) have shown, that at least as far east as the mouth of Wadi Rama, this plain is divided into wide basins by lines of low hills running north from the *jol* to the sands.

[2] *Shaqqa*, pl. *shiqaq*: the "valleys" between parallel dune chains (*'urug*).

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slip faces to the north-west. Near the Taiyyibat al 'Ism the orientation is to 250° with a well marked line of riders at 215° some of which extend over the *shaqqa* floor giving a reticulated pattern. The slip face here also is to the north-west. /133

South of the Mutbathat as far as the Shaqqat al 'Itima, *i.e.* the *shaqqa* into which the Wadi 'Itima flows, lie the Qa'amiyat sands. These dunes, with a height of over 200 feet, are the highest dunes of the south-west Rub' al Khali. They are oriented to 220° with no pronounced slip face, and due to their width the *shiqaq* between them are always narrow and frequently eliminated. They carry riders at 210° which have the slip face to the south-east.

South of the Shaqqal al 'Itima and east of the Sauda scarp which penetrates 30 miles into the sands there are two distinct orientations of the dunes. The easterly section, which lies back from the foot of the scarp, consists of about sixty dune chains less than a mile apart and generally oriented to 245°. Along a distinct line between 17° 15′ N., 45° 45′ E. and the Raiyan hills these dunes coalesce in groups to form only twenty-five dunes oriented to 225°. The slip faces of all these dunes is to the south, and there is no distinct line of riders. A large number of neolithic flints were found at 17° 12′ N., 45° 55·2 E. (Plate 6).

At the northern tip of the Sauda scarp, where it sinks into the desert floor, both floor and scarp are concealed by small south-west facing crescentic dunes 4–6 feet high. East of the Sauda the sands lie back as is the case with the Ardh scarp, but the six most southerly dunes of the sand desert approach to within 2 miles of the top of the scarp. North of them lies an area of sand sheet, the Bagheithan plain, with a few scattered dunes oriented in 250°. The plain may be traced some 20 miles east, and the dunes become more abundant and regular, until by 47° 45′ E. the full pattern of parallel dunes with intervening *shiqaq* is redeveloped (Plate 7). The dune line about twentieth from the south was followed eastward from here (Plate 8). In 17° 50′ N., 48° 10′ E., there is a distinct change in orientation from 252° (to the west) to 244° (to the east), which may be correlated with a more gradual curve through the same range made by the dunes to the south near the Khashm al Jebel. The orientation of the riders is 10° greater than that of the dunes, and the slip faces to the south. For the next 80 miles east there is a series of minor direction changes always between 237° and 243°. In the area about 19° N., 50° E., the *shiqaq* floors become broken into windows by layers of sheet sand perpendicular to the general line of the dunes, and during the next 30 miles east these sheets take a more and more pronounced form till they become as high as the original dune lines, and the straight lines of *shiqaq* become confused in an area of reticulations.

A small area of dune massifs exists near the Khashm al Jebel, occupying the narrow triangle between the most southerly dune and the edge of the *jol*. The massifs lie on the nodes of a hexagon net and do not continue east of the mouth of the Wadi Hizar except for a few isolated examples known as "qa'id" on the gravel *jau*. The slip faces of all these massifs are to the south-west.

15: Bunker N-4 (ca. 1950) 1953 MM2 Hadhramaut MM2

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